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DEPARTMENTS

Principal paper . . . . . page 13
Events . . . . . " 15
Proceedings . . . . . page 18
Publications . . . . . " 19

PRINCIPAL PAPER

L I C H E N S A N D A I R P O L L U T I O N

Clifford W. Smith [1/]

It is now a well-established fact that some plants are extremely sensitive to air pollution. It is impossible without adequate cleansing of the air to grow spinach and several other vegetables within 15 miles of downtown Los Angeles. The recent death in the ponderosa pines in the mountains surrounding Los Angeles has been attributed to high levels of ozone. The loss of the epiphytic flora on treetrunks in European and other cities has long been attributed to air pollution particularly sulphur dioxide. It is on the subject of air pollution and the epiphytic flora in Honolulu that I wish to address myself.

Lichens are a symbiotic association between an alga and a fungus. The alga acts as the producer supporting its own growth and reproduction as well as that of the fungus. One of the most intriguing questions in biology today is how that delicate balance between the two symbiotic life forms is maintained without one completely dominating the other. In such a system it is obvious that any factor which will disturb the balance will seriously jeopardize if not destroy the symbiotic association.

Lichens are said to be tolerant of wide fluctuations of temperature, humidity and other environmental parameters. Like many generalizations this one is an exaggeration of a half truth. Many lichens can survive through long periods of dessication. In the dehydrated condition they are relatively stable in wide fluctuations of temperature and they are also immune to the vagaries of various noxious substances. However, in the hydrated condition they are as susceptible as any other organism if not moreso

1/ University of Hawaii, Dept. of Botany. Address of the retiring President of the Hawaiian Botanical Society, December 7, 1970.

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because of their dual character. As it so happens lichens are very sensitive to environmental poisons present during their active phase of growth because the very delicate balance between the alga and the fungus is readily disturbed. Air pollutants, particularly SO_2, decrease the activity of or kill the phycobiont with the consequent death of the lichen. If only mild toxicity is applied the organism may be able to survive but only as a sterile thallus.

There are certain lichens which thrive in our polluted cities. In Great Britain Lecidea conizaeoides is more or less confined to industrial areas. Certain species of Stereocaulon are also quite abundant on the soil in cities. It seems that crustose and foliose species growing on trees and rocks are susceptible whereas species growing on the soil are not. The reasons for this are not immediately apparent. However, the soil may absorb SO_2 thereby reducing the ambient SO_2 to harmless levels. Asbestos tiles, which are efficient absorbers of SO_2, support luxuriant lichen populations in areas surrounding industrial areas. A question that has always bothered me is why does Lecidea conizaeoides thrive in polluted regions?

It has recently been reported that the establishment of lichens is acutely affected by only moderate quantities of air pollution. However, pollution resistant forms are still capable of establishment in polluted atmospheres. If SO_2 is the major toxicant they are probably capable of rapidly converting the SO_2 into relatively harmless sulphates.

There are atmospheric pollutants other than SO_2 which is a minor constituent of smogs. The deleterious effects of ozone and peroxyacetyl nitrates are well known but their effects on lichens are unknown.

Finally, we know that lichens can very efficiently absorb many substances from their environment. This point has been very amply demonstrated in Arctic Regions where Cladonia rangifera (Reindeer Moss) has absorbed large quantities of radioactive wastes in rainwater as a consequence of nuclear test fallout. The caribou eats the lichen and further concentrates the radioactive particles. The caribou is also a major dietary item of the Eskimos many of whom now have high doses of radioactive substances in their bodies.

The capacity of lichens to absorb substances and then concentrate them is probably the result of their almost sponge-like affinity for water. Any dissolved or suspended particles or substances will be taken into the plant body. The lichen has no mechanism for excreting toxic substances but simply stores them or incorporates them into other substances and thereby hopefully neutralizes them. This incorporation can proceed only so far before the detoxified substance itself becomes toxic with consequent incapacitation or death. The problem is further compounded by the fact that as the net water content of the thallus is decreasing during dessication, the concentration of the pollutant is increasing.

When one considers the above situation with reference to lead or other heavy metal pollutants we have only delayed the presentation time of the pollutant to other organisms. Once the lichen is dead it will drop to the ground and there it will decompose releasing its stored toxic materials.

Rydzak has pointed out that cities tend to be hot deserts with a climate of high temperature fluctuations and low relative humidity. During the daylight hours the white concrete reflects the incident light and infra-red radiation so that light and heat strike all portions of any upright object from all angles. Thus the trunk of a tree is no longer shaded and being of a dark colour absorbs the heat. The black

tarmac road absorbs all radiation and becomes warm reradiating heat. Thus everything becomes decidedly warmer. At night the black road radiates all its heat away quickly and there is a consequent sharp drop in temperature. The elevated temperature also means a reduced relative humidity which can be elevated only by a decrease in temperature or a rain shower. There is no abundant source of water from transpiration or the evaporation of water from the soil as in most naturally vegetated areas. Indeed, we very adroitly funnel away any rainwater from our streets. Just conjure up the difference between sitting in the shade of a tree along a thoroughfare as compared with the same situation in the shade of a tree in one of our parks. If you were to compare the lichen flora in the two areas the correlation between lichen flora and locality is striking.

Another negative factor in the establishment of lichen species on tree trunks is the presence of a viable population in the immediate area. The trees that "landscape architects" plant to "beautify" our streets are generally young saplings grown in an area divorced from the planted area. Thus, with the uprooting of trees during construction, the consequent planting of trees that are generally devoid of lichens and the very slow growth rate of lichens could account for their absence in urban environments.

In a city such as Honolulu where the trade winds blow from the forested areas out to sea there is a fairly continuous supply of spores or vegetation fragments to reinfect the trees. As pointed out earlier, the establishment of lichens is susceptible to very low concentrations of pollutants. With this in mind it is interesting to compare the young coconut trees on the Ala Wai Boulevard and coconut trees on Kalakaua Avenue in Waikiki. The trees along the Ala Wai have small lichen colonies, those along Kalakaua do not. Apart from the fact that Kalakaua is blocked in by buildings whereas the air along the Ala Wai blows over the canal and is presumably more humid the traffic patterns differ. The Ala Wai traffic is fast moving with rare stops, that is, most automobile engines are working efficiently. The Kalakaua traffic is slower with frequent stopping and starting and a greatly increased polluted exhaust emission. Side streets around Kalakaua Avenue which are less heavily used have coconut trees with respectable lichen communities on them. The only conclusion I can draw is Kalakaua Avenue is polluted. The question is how bad is the pollution particularly on windless days?

Prevailing opinion favours the conclusion that when lichens are not found on trees in urban and industrial communities it is a very good indication that the air is polluted. With this in mind it is disturbing to note that most of the trees on the roadside of our major thoroughfares and city streets do not support epiphytic communities. The problem is further compounded by the continued decline in the plant community as a consequence of construction. Nimitz Highway continues to be an eyesore for incoming and departing visitors. Our folly lies in our failure to understand that plants not only absorb much of the air pollution but also decrease noise pollution.

EVENTS

Ohia Decline

The American Forestry Association sponsors a group called "Trees for People Task Force". At a meeting January 15, 1971, the Task Force resolved to seek increased federal appropriations for cooperative forest fire protection and research for insect and disease control. One of the items on the list of recommended increases in appropriations needed to improve technology for control of forest insects and disease is:

Decline of ohia-koa forests, Hawaii, $75,000, 1 scientist.

Field Tour to Waimanalo Experiment Station Arboretum

The field tour conducted by Dr. Robert M. Warner, on March 7 was attended by 30 persons. It is reported to have been very well received.

Overseas Technical Assistance Programs

The Horticulture Department has several members serving overseas on a variety of programs. This list is incomplete and may err in some details but it will give some idea of the kinds of activities (Ed.):

THAILAND - Dr. Yukio Nakagawa - Consultant in vegetable production; - 3 months.
GHANA - Dr. Philip Ito - Fulbright Scholarship teaching award. At University to give instruction in fruit improvement ; one year.
GUAM - Dr. Fred Rauch - Extension Specialist in Horticulture, Consultant ornamentals; 1 month.

Other Overseas Services

Wesley Wong of the Hawaii Division of Forestry has recently returned after more than one month at Subic Bay Naval Base, Philippine Republic, to prepare a forest management plan.

R. E. Nelson, Craig D. Whitesell and Roger Skolmen of the Institute of Pacific Islands Forestry have been studying forestry problems in Guam. Nelson also accompanied Wong to the Philippine Republic for the beginning of the project mentioned above.

Island Ecosystem Stability and Evolution (A brief progress report of the Hawaii IBP)

This subprogram is concerned with the study of terrestrial ecosystems that evolved in complete isolation in the midst of the Pacific Ocean (Hawaiian Islands).

The uniqueness of this isolation is the presence of the same principal environmental components as in many tropical mainland ecosystems, but with the point of departure that the biotic component was extremely restricted in origin. This original biotic component has evolved into a diversity of its own.

The main problem in the island ecosystems is that to the endemic diversity has been added a non-evolutionary diversity through man-introduced biota. A competitive struggle is going on in many ecosystems that threatens to wipe out the endemic diversity in several of the island habitats. However, man has been the principal direct factor in lowering the resistance of the endemic island ecosystems.

This subprogram aims at uncovering the fundamental causes in this competitive struggle to gain insights into the stability-fragility relations of those native ecosystems where the direct interference of man was held at a minimum. This requires observations also in man-disturbed ecosystems for experimental comparisons.

Strategy and objectives

These are directed toward

Intensive studies of a few selected ecosystems whose species composition and structure has been the result of island evolution.

The main questions asked are:

1. What is the nature of their compositional and structural variation?
2. What are their directions of development?
3. What are their rates of population change or maintenance?

Comparisons of ecosystems along well defined environmental gradients (transects) to study the factors and mechanisms responsible for changes in ecosystem stability.

The main questions asked are:

1. What is the effect of physical environmental change on stability along the transects?
2. Of what nature are the interrelations of diversity and stability along the transects?
3. What is the relationship between life form composition and distribution (structure), regulatory organisms (dominants) and stability along the transects?

Comparisons of successful endemic populations regarding their mechanisms of adaptation to the island ecosystems.

The main questions asked are:

1. Why do some of the successful biota show incomplete speciation, while other successful ones show fragmentation into many species?
2. What factors determine their relative success?
3. What are the rates of speciation?

Eventual comparison of the stability of island ecosystems to environmentally and structurally similar continental ecosystems.

Current activities

A. Intensive study of selected ecosystems

A comprehensive ecological survey was begun in a 200 acre site occupied by a native montane forest ecosystem. The principal structural components are scattered, tall, big-diameter Acacia koa trees and groups of Metrosideros polymorpha with several other native tree species as subcanopy members. A third major biomass stratum is formed by tree ferns (Cibotium spp.).

The base lines were surveyed and two 1000 m long transects were flagged out with 10 plot points at intervals of 200 m. The first sample plot has been completed. In addition to the plant ecological survey, insect and bird surveys are carried out along the same transects. Malaise traps and attractant logs have been placed at various strategic positions in this forest.

A climatic station was installed in August at this site for continuous recording of temperature and humidity. Rainfall in the open and under trees is checked at weekly intervals. Precipitation measurements under the canopy are particularly important here, because of the suspected high moisture contribution from cloud interception.

Check lists of all biota in this forest are currently prepared, and further sampling techniques are being worked out. Nine investigators are contributing to this study.

B. Ecosystem transect study

Six ecosystem transects have been defined and described on Hawaii. These range from 10-22 miles in length. One of these extends from the top of Mauna Kea (near 14,000 feet elevation) to the sugar cane fields above Hilo. Another lies parallel to the Mauna Kea transect on the east flank of Mauna Loa, where it traverses similar climates but much younger substrates. The four remaining transects are in Hawaii Volcanoes National Park and extend the Mauna Loa transect down to sea level.

Most of the 30 principal ecosystems along these transects have been studied by about two 500 m^2 vegetation samples each. The plot locations are currently transferred on a new 1:24,000 vegetation map, which is prepared under this subproject. Field work for the map is completed. Sixty-two plant check lists with quantitative information on species cover are currently programmed for computer storage, retrieval and various summaries to be available for any project participant. The same will thereafter be done with the insects and other biota checklists that are coming forth in the near future. Nine investigators have so far contributed to the transect study principally by attempting to establish the diversity of their particular biota in the various ecosystems and by defining the amplitudes of species along the transects. Seven phenological and two climatic stations were established in different macroclimates along the transects.

C. Evolution studies on endemic populations

Most of this work has been done along the transects, but some highly specialized populations, such as the Hawaiian Diptera and certain Hawaiian birds have been followed into different areas. The same is true for the genecological studies of the widely distributed polymorphic tree Metrosideros. The evolutionary objectives are pursued on all major islands, particularly on Hawaii, Maui and Kauai. They are not necessarily tied to the transects.

The ecological studies will be extended eventually also to Maui and Kauai.

Submitted for inclusion
in the Progress Report of the

ORIGIN AND STRUCTURE OF ECOSYSTEMS main project
by

Dieter Mueller-Dombois
Scientific Coordinator
Hawaii International Biological Program

PROCEEDINGS OF THE SOCIETY

(Highlights only; not the complete minutes)

February 1, 1971

1. New membership chairman - Ruth Gay
   Members, Mrs. McLain, Gagne, Purdy, Meredith, Smith, Hartmann.

2. Foster Garden tour postponed until April.

3. Dr. Brash reported on dedication ceremonies of the Pacific Tropical Botanical Garden, Lawae, Kauai.

4. Robert Osgood requests information on plant collections (living) in Hawaii.

5. Speaker of the evening, Gregg Stanton, "Holoholo with the auhuhu". This is a method of fish poisoning which was used by the Hawaiians in earlier times. Mr. Stanton has successfully performed the process with help from Hawaiians.

6. Mrs. Mapes showed tiny silversword plants grown from excised tissues in culture.

March 1, 1971

1. Milton Manhoff and Walter Holt are co-chairmen of the Science Fair Committee. Science Fair judges are authorized to award $40.00 appropriated by the Botanical Society.

2. Ala Moana Park tour postponed until April or May.

3. Speaker of the evening, Paul G. Scowcroft, Research Forester, Institute of Pacific Islands Forestry, "Koa, Monarch of Hawaiian Forests."

Proposed Changes in Constitution

Revisions in Articles V and VI (Section 1) of the Hawaiian Botanical Society have been proposed by the Executive Committee, and will be voted upon at the May meeting of the Society.

Revised articles will read as follows:

ARTICLE V. Executive Board

The President, Vice-President, Secretary, Treasurer, Membership Chairman, Editor of the Society Newsletter, and two Directors shall constitute the Executive Board. The Executive Board shall plan the programs of the meetings and execute the mandates of the Society.

ARTICLE VI. Committee

Section 1. Membership Committee. Directly after the Annual Meeting, the President shall appoint a Membership Committee composed of a chairman and two or more members. Any member of the Membership Committee may present names of nominees to the Society for membership.

In Article V, underlined words have been added.
In Article VI, underlined words have been added.

PUBLICATIONS

Recent Literature

(Note: Literature references are listed alphabetically on a round-robin basis to the extent needed to fill out the nearest odd numbered page. Thus, the last listing in the February issue was an "N", so this time we begin with the next alphabetical listing which is a "P".

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THE HAWAIIAN BOTANICAL SOCIETY NEWSLETTER is published in February, April, June, October, and December. It is distributed to all Society members for the purpose of informing them about botanical news and progress in Hawaii and the Pacific. News contributions and articles are welcomed.

Editor Russell K. LeBarron
(Hawaii Division of Forestry)

THE HAWAIIAN BOTANICAL SOCIETY was founded in 1924 to "advance the science of Botany in all its applications, encourage research in Botany in all its phases," and "promote the welfare of its members and to develop the spirit of good fellowship and cooperation among them." Any person interested in the plant life of the Hawaiian Islands is eligible for membership in this Society. Dues, regular, $3.00 per year; college students, $2.00; students below college level, $1.00.

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